Search for hyper-matter with ALICE at the LHC*

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The unique particle identification capabilities of the ALICE detector [1] allow for the measurement of rarely produced exotic states created in Pb–Pb collisions. This also gives the opportunity to search for hypothetical states like the Λn bound state and the H-Dibaryon, a six quark state ($uuddss$), which was already predicted in 1977 [2] using a bag model calculation.

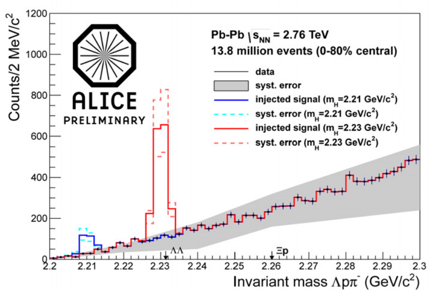

Figure 1: Invariant mass of $\Lambda + \mathrm{p} + \pi^-$.

Since current theoretical discussions favour a low binding energy - if bound at all - for the H-Dibaryon, we concentrate on the mass region of 2.2-2.3 GeV/c^2 in the decay channel $\Lambda \mathrm{p} \pi$. In this channel a signal for a bound state would result in a peak in the invariant mass distribution or in a broad structure above the $\Lambda\Lambda$ threshold in case of a resonant state. In a similar way, we also study here the possible decay of a Λn bound state decaying into d+π^- which was observed at GSI by the HypHI collaboration [4] at a mass of 2.054 GeV/c^2.

The results shown here for the H-Dibaryon and the $\overline{\Lambda \mathrm{n}}$ bound state are based on the analysis of about 13.8 million Pb–Pb events in the centrality class of 0-80% taken with the ALICE apparatus in 2010. We focus here on the $\overline{\Lambda \mathrm{n}}$, since the experimental background is much lower compared to Λn. The reconstructed invariant mass distributions are shown in figure 1 and 2. No evidence for a signal, neither for the H-Dibaryon nor the $\overline{\Lambda \mathrm{n}}$ bound state was found. The figures 1 and 2 also show the expected signal for the H-Dibaryon for two assumed masses of 2.21 GeV/c^2 and 2.23 GeV/c^2 (corresponding to binding energies of 21 MeV and 1 MeV) and a possible $\overline{\Lambda \mathrm{n}}$ signal. The expected signal was computed estimating the acceptance $\times$ efficiency (from a Monte-Carlo simulation), the

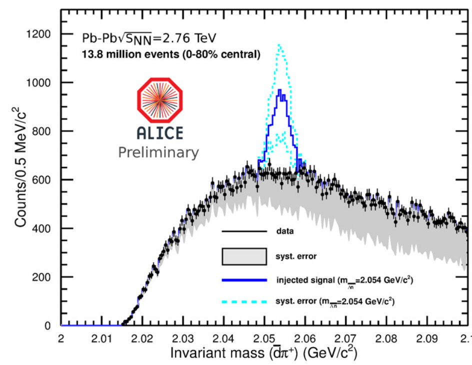

Figure 2: Invariant mass for $\overline{\mathrm{d}} + \pi^+$.

production rates as predicted by the thermal-model [5] and the predicted branching ratios [3, 6]. For the Monte-Carlo simulation, involving full decay kinematics and transport in the material utilizing GEANT3, the lifetime of the free Λ hyperon was assumed for both exotic states. We calculate upper limits for the production yields:

H-Dibaryon: dN/dy $(m_{\mathrm{H}} = 2.21\, GeV/c^2) \leq 8.4 \cdot 10^{-4}$
dN/dy $(m_{\mathrm{H}} = 2.23\, GeV/c^2) \leq 2 \cdot 10^{-4}$
$\overline{\Lambda \mathrm{n}}$ bound state: dN/d$y \leq 1.5 \cdot 10^{-3}$

The extracted limits are a factor of 10 lower than the thermal-model predictions [5] used to estimate the expected signal while these successfully describe the yields measured by STAR for the hypertriton [7] within uncertainties [8]. The results shown here are described in more details in [9].

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